FLUID MACHINERY
(MECH 2201)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) In a centrifugal pump, the flow is
(a) radially inward (b) radially outward
(c) tangential to rotor blade (d) axial.

(ii) Shut-off head of a pump is the head developed at
(a) zero impeller speed (b) zero input power
(c) zero discharge (d) maximum efficiency.

(iii) Muschel curves mean
(a) curves at constant head (b) curves at constant speed
(c) curves at constant discharge (d) curves at constant efficiency

(iv) For a mixed flow pump
(a) head is more and discharge is less
(b) both discharge and head are very high
(c) discharge is more and head is less
(d) both head and discharge are moderate.

(v) Pelton turbine is a
(a) impulse turbine
(b) reaction turbine
(c) may either impulse or reaction turbine
(d) axial flow turbine.

(vi) NPSH is the abbreviation of
(a) Net Pressure and Suction Head
(b) Nominal Positive Suction Head
(c) Net Positive Suction Head
(d) Net Positive Static Head.

(vii) The unit speed N_u of a turbine of rotational speed N and head H is equal to
(a) $N\sqrt{H}$ (b) $N/\sqrt{H}$ (c) $\sqrt{H}/N$ (d) $\sqrt{HN}$

(viii) Efficiency of Pelton wheel shall be maximum, if the ratio of jet velocity to tangential velocity of the wheel is
(a) 0.5 (b) 1 (c) 2 (d) 0.75.

(ix) The reciprocating pumps are useful for the application of
(a) high head and low discharge (b) high head and high discharge
(c) low head and high discharge (d) low head and low discharge

(x) During suction stroke of a reciprocating pump, the flow separation may take place
(a) at the end of suction stroke
(b) in the middle of suction stroke
(c) in the beginning of suction stroke
(d) separation never occur.

Group – B

2. (a) With sketch of velocity diagrams, show that in case of a centrifugal pump, the ideal head rise across impeller blade is given by

$$H = \frac{U_2^2 - U_1^2}{2g} + \frac{V_2^2 - V_1^2}{2g} + \frac{Vr_1^2 - Vr_2^2}{2g}$$

where U = tangential speed of impeller, V = absolute flow velocity V_r = relative flow velocity; 1: inlet to impeller blade, 2: outlet of impeller blade.

(b) Compare radial, axial and mixed flow pump based on head developed and discharge. Explain why backward curved vane is preferred over forward curved vane in case of centrifugal pump impeller.

6 + (3 + 3) = 12

3. (a) A centrifugal pump having outer diameter equal to two times the inner diameter and running at 1200 rpm works against a total head of 75 m. The velocity of flow through the impeller is constant and equal to 3 m/s. The vanes are set backward at an angle of 30° at outlet. If the outer diameter of the impeller is 600 mm and width at outlet is 50 mm, determine: (i) the blade angle at inlet (ii) work done by impeller on water per second (iii) discharge through impeller (iv) manometric efficiency. Assume no swirl at inlet.

(b) What are the functions of (i) impeller eye and (ii) volute casing in centrifugal pump?

8 + (2 + 2) = 12

Group – C

4. (a) Differentiate between Impulse and Reaction turbine.

(b) Why draft tube is used in reaction turbine?

(c) The hub diameter of a Kaplan turbine working under a head of 12 m, is 0.35 times the diameter of the runner. The turbine is running at 100 rpm. If the vane angle of the extreme edge of the runner at outlet is 15° and flow ratio is 0.6, find (i) diameter of the runner and (ii) discharge through the runner. Given the velocity of whirl at outlet is zero.

2 + 2 + (4 + 4) = 12

5. (a) Two jets strike the buckets of a Pelton wheel, which is having shaft power as 14,715 kW. The diameter of each jet is given as 150 mm. If the net head on the turbine is 500 m, find the overall efficiency of the turbine. Take $C_v = 0.98$.

(b) An elbow type draft tube has a circular section of 1.5 m^2 at the top and a rectangular cross section of 12.5 m^2 at the exit section. The turbine is set at a height of 2 m above the tail race level. If the velocity at inlet to the draft tube is 12 m/s, estimate the (i) negative pressure head at the inlet to the draft tube, (ii) power wasted to the tail race and (iii) efficiency of the draft tube. Assume the frictional losses in the draft tube to be 15% of the inlet velocity head.

6 + 6 = 12

Group – D

6. (a) Draw the operating characteristics (H-Q, P_{in}-Q, η-Q) of a centrifugal pump. Show the system resistance curve in the same diagram and locate the operating point and design point.

(b) A single stage centrifugal pump with impeller diameter of 300 mm rotates at 2000 rpm and lifts 3 m^3/s of water to a height of 30 m with an efficiency of 75%. Find the number of stages and diameter of each impeller of a similar multistage pump to lift 5 m^3/s of water to a height of 200 m when rotating at 1500 rpm.

(3 + 3) + 6 = 12

7. (a) Define and derive the expression of 'unit discharge' and 'unit power' with reference to a hydraulic turbine.

(b) A centrifugal pump has a rotational speed of 1200 rpm, a design discharge of 0.5 m^3/s and a head of 20 m. The shut-off head is 30 m. For what speed of the pump, will the discharge be 0.6 m^3/s? What will be the corresponding head? For what speed will the shut-off head be 22m?

(3 + 3) + 6 = 12

Group – E

8. (a) Explain the working principle of a single acting reciprocating pump.

(b) A single acting reciprocating pump having a cylinder diameter of 150 mm and stroke of 300 mm is used to raise water through a height of 20 m. Its crank rotates at 60 rpm. Find the theoretical power required to run the pump and the theoretical discharge. If actual discharge is 5 litre/s, find the percentage slip. If delivery pipe is 100 mm in diameter and is 15 m long, find the acceleration head at the beginning of the stroke.

4 + 8 = 12

9. (a) Draw and explain the diagram of rate of delivery vs crank angle for double acting reciprocating pump.

(b) A reciprocating pump has a suction head of 6 m and delivery head of 15 m. it has a bore of 150 mm and stroke of 250 mm and piston makes 60 double stroke in a minute. Calculate the force required to move the piston during the (i) suction stroke, (ii) delivery stroke. Find also the power to drive the pump.

4 + 8 = 12